Four-equation Models for Rayleigh–Taylor Mixing

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1. Introduction

An investigation of single fluid models for Rayleigh-Taylor mixing is presented with reference to high-resolution implicit Large Eddy Simulations (iLES). The study primarily focuses on a new four-equation K-L-α-b, which includes an equation for the density-specific volume covariance b, and the Besnard-Harlow-Rauenzahn model (BHR-2) [1]. Furthermore, comparisons are presented with the two-equation K-L [2, 3]. All models are implemented in the same numerical framework to minimize the computational uncertainty. The flow physics predicted by the turbulence models is investigated for canonical Rayleigh-Taylor mixing, and for the tilted-rig problem.
Model complexity is increased in a gradual and systematic manner by introducing either additional variables or terms in order to identify the advantages (and disadvantages) offered. The two-equation K-L model is used as the starting point. The turbulence models considered here invoke the Boussinesq approximation for the Reynolds stresses aiming at obtaining a detailed understanding of the capabilities and limitations of simpler models before studying more complex models in the framework of second moment closures.
The effects of the various modeled terms is discussed and important conclusions for the accuracy and the limitations of the four equation models are drawn. Several modifications that increase the accuracy and numerical stability of the models are also proposed.

2. Results

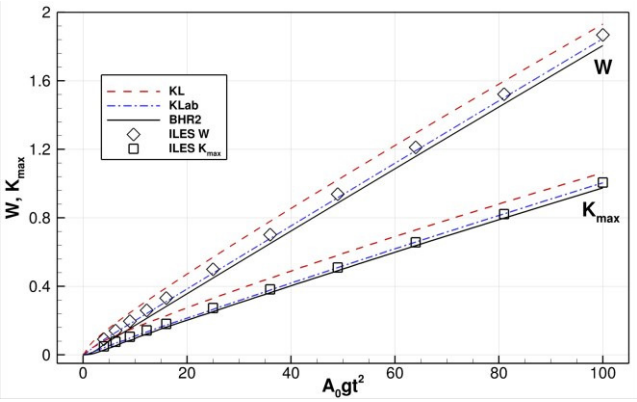

Figure 1: Self-similar growth of W and K_{max} for 3:1 RT.

Implementation of the modified species turbulent diffusion term (MSTD) [4] into the 4-equation models, offers a significant improvement to the volume-fraction distribution in the tilted-rig case over the standard Fickian-like gradient diffusion approximation. As in [3], the importance of the correct treatment of the turbulent enthalpy flux is highlighted.

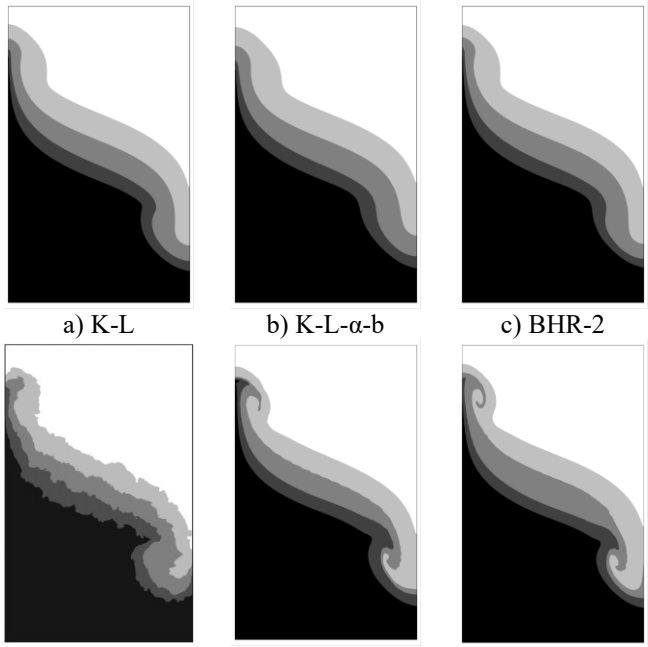

Figure 2: Volume-fraction contour plot at scaled time 1.741; [0.025, 0.3, 0.7, 0.975].

References

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